WBS: 1.2.6
QA: N/A

Civilian Radioactive Waste Management System
Management and Operating Contractor

Title III Evaluation Report for the Muck Storage

BABCC0000-01717-5705-00001 Rev. 2

August 10, 1998

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:

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1180 Town Center Drive
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Under Contract Number
DE-AC08-91RW00134

Civilian Radioactive Waste Management System
Management and Operating Contractor

Title III Evaluation Report for the Muck Storage

BABCC0000-01717-5705-00001 Rev. 2

August 10, 1998

Prepared by:

Hector R. Montalvo, Technical Document Preparer — Date: 8/10/98

Approved by:

William R. Kennedy, Department Manager — Date: 8/13/98

TITLE III EVALUATION REPORT
MUCK STORAGE
(BABCC0000)

1. OBJECTIVE

1.1 Introduction

This Title III Evaluation Report (TER) provides the results of an evaluation that was conducted on the Muck Storage System. This TER has been written in accordance with the *Technical Document Preparation Plan for the Mined Geologic Disposal System Title III Evaluation Reports* (BA0000000-01717-4600-00005 REV 02).

1.2 Objective

The objective of this evaluation is to provide recommendations to ensure consistency between the technical baseline requirements, baseline design, and the as-constructed Muck Storage System. Recommendations for resolving discrepancies between the as-constructed system, the technical baseline requirements, and the baseline design are included in this report. Cost and Schedule estimates are provided for all recommended modifications.

This report does not address items which do not meet current safety or code requirements. These items are identified to the CMO and immediate action is taken to correct the situation. The report does identify safety and code items for which the A/E is recommending improvements . The recommended improvements will exceed the minimum requirements of applicable code and safety guide lines. These recommendations are intended to improve and enhance the operation and maintenance of the facility.

1.3 Methodology

The methodology used in the Title III Evaluation Reports of the Muck Storage System consists of the following activities:

- a field investigation to inspect the as-constructed system;
- comparison of the as-constructed system with the ESF design requirements (e.g., ESF design requirements, operational requirements, and S&H requirements) to determine if the as-constructed system satisfies the requirements;

- a review of Level 3 design documents, field investigation data, and as-constructed documentation to determine deviations between the design and as-constructed Muck Storage System;
- a review of operational requirements to determine if the as-constructed system is capable of performing/supporting the operational requirements; and
- development of recommendations to resolve discrepancies.

2. SCOPE

This TER covers the Muck Storage System. The area used is the Optional Muck Storage Area and is located east of the North Portal Pad and west of the North Portal Pad road. The total calculated area for the storage pile is approximately 398,000 square feet with a capacity of approximately 525,000 cubic yards with provisions for additional capacity.

3. QUALITY ASSURANCE

The purpose of this TER is not to implement QA controls associated with the Muck Storage System. Rather, this document identifies those QA controls which continue to be applicable to the operation of the system. The implementation of QA control is specifically addressed in the design drawings and specifications for the Muck Storage System.

This evaluation does not comprise a QA design input. The Systems, Structures, and Components to which it applies are not classified in accordance with QAP-2-3, *Classification of Permanent Items,* and do not rely on or incorporate any QA controls identified within any applicable Determination of Importance Evaluation (DIE). Preparation of this evaluation is not subject to *Quality Assurance Requirements and Description* requirements. QA: None.

4. FIELD INSPECTION

4.1 Summary: The field inspection was performed by walking the entire Muck Storage Area. A visual inspection was made of the storage pile using the design drawings. The inspection included visually checking the side slopes and checking if the drainage ditches were installed on the west side of the pile as per design, (Ref 9.3). This TER is based on the information gathered on this inspection.

4.2 Date: April 15, 1997

4.3 Participants: Tony Saltikov M&O/Test Facilities Design
Hector Montalvo M&O/Test Facilities Design
Gary Teraoka M&O/Systems Engineering and Integration
Mike Heiner M&O/Construction Management

4.4 Records Reviewed:

Drawings
Optional Muck Storage Area
BABB00000-01717-2100-20082 Rev 01 Grading Plan, Sheet 1 of 2

BABB00000-01717-2100-20083 Rev 01 Grading Plan, Sheet 2 of 2
BABB00000-01717-2100-20085 Rev 01 Storm Drain Optional Storage Area, Plan and Profile

As-Constructed Drawings
Topography of South End of Muck Pile ESF North Pad

4.5 Results:

The muck storage pile generally follows the area shown on the design drawings. The slopes on the south half of the pile are a minimum of 2 to 1. This can be verified from the as-constructed drawing prepared by the Construction Management Organization. A preliminary visual observation of the muck pile indicated that the slopes on the north half of the pile are steeper than 2 to 1. No as-constructed information was available for the north half of the pile at the time of this inspection. To verify the slopes on the north half of the pile a topographic survey was prepared and issued on May 20, 1998. The results are shown on Attachment I.

5. OPERATIONAL REQUIREMENTS

5.1 System Description

Muck is removed from the ESF tunnel by conveyor and muck car and transported by conveyor to the Muck Storage pile where it is picked up by end loaders and carried to the top of the pile and dumped and spread out.

5.2 Operating Parameters

Table 5.2-1 Operating Parameters

Operating Parameters	Reference	Discussion
The Muck Storage area is designed for a capacity of 525,000 cubic yards.	9.1	The Muck Storage area has been constructed to provide the design capacity specified.
The Muck Storage Pile shall be limited to a maximum height of fifty feet.	9.7	The height of the north half of the pile is two feet below the fifty foot limit.

5.3 Operating Permits

Table 5.3-1 Operating Permit Requirements

Operating QA Controls	Reference	Discussion
State of Nevada Stormwater General Discharge Permit dated May 14, 1993.	9.8	The design drawings for the Muck Storage Pile are part of the general discharge permit and specify 2 to 1 side slopes for the pile.

5.4 Operating S&H N/A

5.5 Operating Quality Assurance (QA) Controls.

The operating QA controls listed in Table 5.5-1 were extracted from Specification Section 01800 Maintenance and Operations of Surface Facilities, Document Number BAB000000-01717-6300-01800 Rev 01.

Table 5.5-1 Operating QA Controls

Operating QA Controls	Reference	Discussion
Calico Hills excavated muck shall not be stored in the ESF Muck Storage Area without A/E evaluation (Which must include potential waste isolation impacts) and approval. Muck excavated from the Calico Hills shall have stabilization of the muck storage piles to prevent eronite or mordinite fibers from being suspended in the air.	9.5	No Calico Hills excavation has been done.
The Muck Storage Pile shall be limited to a maximum height of fifty feet.	9.7	The height of the muck pile is 48 feet, checked at the highest point (being on the north half) which is 2 feet less than the design allowable height.

6. BASELINE REQUIREMENTS

6.1 ESFDR REQUIREMENTS - Comparison of the ESFDR to the as-constructed system.

Table 6-1 compares the as-constructed system configuration with the applicable requirements of the ESFDR. If the requirement is satisfied, a description of how the requirement is fulfilled is provided in the table. If the requirement was not satisfied, a recommendation is provided of how the system or requirements should be modified to resolve the noncompliance.

Table 6-1 ESFDR Requirements

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied?**	**Description**
3.2.1.2.1.1.A The ESF surface facilities and equipment shall be designed with features that minimize the growth of fungus, bacteria, and algae.	N/A	Fungus, bacteria and algae are not a consideration in the design of Muck Storage.
3.2.1.2.1.1.B Earthquake design parameters for surface facilities shall be calculated in accordance with the information in Appendix A, Seismic Design Basis Loads for the Exploratory Studies Facility.	Yes	The Muck pile was designed to conform with the requirements specified in the Uniform Building Code (UBC) for Zone 2B. The Earthquake design parameters listed in Appendix A conform with the requirements specified in the UBC for Zone 3. The latest parameter is more conservative since it accounted for ground motion produced by nuclear tests. There is presently a moratorium on nuclear testing and it is unlikely that it would be lifted in the future. **Recommend:** Revise the ESFDR to change the peak ground acceleration to 0.2 g to conform to Zone 2B of the UBC.
3.2.1.2.1.1.C The ESF surface facilities shall be designed to withstand 75 mph (high winds) prevailing winds with maximum gusts up to 97 mph.	N/A	Forces due to wind are not applicable to Muck Storage.
3.2.1.2.1.1.D The ESF surface facilities and equipment shall be designed with appropriate grounding to withstand and minimize the potential for damage due to a direct lightning strike.	N/A	Grounding does not apply to Muck Storage.

3.2.1.2.1.1.E The ESF surface facilities and equipment shall be designed to withstand maximum daily precipitation levels of 2.18 inches within a 24 hour period.	Yes.	The top of the Muck pile is sloped to allow for drainage.
3.2.1.2.1.1.F The ESF surface facilities and equipment shall be designed to withstand and operate in temperatures ranging from a low of -14 degrees F to a high of 108 degrees F.	N/A	Temperature is not a consideration of the Muck Storage design.
3.2.1.2.1.1.G The ESF surface facilities and equipment shall be designed to withstand maximum loads caused by snow fall of 10 inches maximum in a 24 hour period.	N/A	Snow loads are not a consideration in the design of Muck Storage.
3.2.1.2.1.1.H The ESF surface facilities and equipment shall be designed to withstand and operate in a relative humidity environment of 13 to 71%.	N/A	Humidity is not a consideration in the design of Muck Storage.
3.2.1.2.1.1.I The ESF surface facilities and equipment shall be designed to withstand the loads caused by a 100 year probable maximum flood local storm identified in the *Reference Information Base,* YMP/93-02.	No	The interception drainage ditch on the west side of the Muck Storage pile has not been installed. **Recommend:** The interception drainage ditch is required and it will be addressed in the Title III Evaluation Report of the North Portal Pad Drainage System.
3.2.1.2.1.1.J The ESF surface facilities and equipment shall be designed to withstand and operate in an environment with sand and dust.	N/A	Muck Storage is not sensitive to sand and dust, therefore this is not a consideration in the design.

3.2.1.2.2.A The ESF non-permanent items shall be designed for a 25 year maintainable service life.	No.	The north half of the Muck Storage Pile is not graded in accordance with the design drawings, which specify 2 to 1 side slopes. 2 to 1 side slopes are a requirement to prevent erosion of the side slopes. **Recommend:** Grade the muck storage pile per design drawings.
3.2.1.2.2.B The ESF permanent items shall be designed for a 150-year maintainable service life.	N/A	Muck Storage is considered a non-permanent item per the ESFDR.
3.2.1.2.3.A ESF construction and operation activities shall be evaluated and monitored as necessary for the purpose of assessing the effects of those activities on the future suitability of the site for a potential repository.	Yes.	ESF construction activities are periodically monitored as muck is placed on the storage pile and water usage is reported in TFM YAP 2-8Q. Muck Storage was evaluated by the applicable DIE.

3.2.1.2.3.B Tracers, fluids, and materials to be used at the ESF shall first be reviewed for potential adverse impacts to waste isolation and site characterization testing. These substances are subject to establishments of controls, and shall only be used following review and approval, and only in those areas where use has been approved. [Such substances include, but are not limited to the following: Concrete and other cementitious materials, such as shotcrete and grout; Ground support materials, including chemical/resin anchorages; Water and any additives to water for identification (tracers) or construction; Hydrocarbons and solvents; Organic materials and combustible materials.]	Yes.	Material used for Muck Storage have been approved and the quantities reported in Tracers, Fluids and Materials Data Reporting and Management, YAP-2.8Q. Bracketed section [ ] of the ESFDR is not applicable to Muck Storage.
3.2.1.2.3.C The presence of combustible materials underground during construction and operation shall be controlled and limited.	N/A	The Muck Storage System is a surface item. Underground requirements do not apply.
3.2.1.2.3.D Within the Conceptual Controlled Area Boundary, the quantity of water used in surface site preparation, construction, and operations shall not exceed an average of two gallons per square yard of application per day, when averaged over five years (excluding water used to mix concrete or shotcrete) or an amount as determined by analysis. The amount of water used for subsurface construction and operation shall be consistent with the amount determined by analysis.	Yes.	Water application is monitored by meters and recorded and reported in accordance with YAP-2.8Q, Tracers, Fluids and Material Data Reporting and Management. The Surface DIE has evaluated the historical application of water at the North Portal Pad and found that the 2 gal /sq. yd/ day limit was not approached.

3.2.1.2.3.E Spills shall be cleaned up to the extent practical. Spilled material and contaminated material (including soil) shall be disposed of in accordance with federal and state requirements, and unrecovered spills will be reported in accordance with tracers, fluids, and materials procedures.	Yes.	All spills and contaminated soils are immediately cleaned up and disposed in accordance with federal and state requirements. Unrecovered spills are reported in accordance with YAP-2.8Q. In addition, stormwater pollution prevention plans such as environmental management plans and preventative measures are implemented in the Constructor's Spill Prevention, Control, and Countermeasures Plan (SPCCP).
3.2.1.2.3.F Dust, vibration, and traffic near sensitive areas shall be controlled during design, construction, and operation (e.g., testing, environmental).	N/A	There are no sensitive areas near the Muck Storage area.
3.2.1.2.3.G All excavation blasting shall be designed to control overbreak to minimize impacts to waste isolation and/or site characterization testing.	N/A	Blasting is not used, therefore it is not a consideration in the design of Muck Storage.
3.2.1.2.3.H All explosives and blasting agents shall be obtained from a qualified supplier, per 27 CFR 55, to limit adverse impacts on in situ site characterization and to limit blasting residue.	N/A	No explosives and blasting agents will be used at the Muck Storage site.
3.2.1.2.3.I Surface construction and/or the location of surface facilities shall avoid the impoundment of surface water which would have adverse effects on the ability of the site to isolate waste.	No.	The interception drainage ditch has not been installed. **Recommend:** The interception drainage ditch is required and it will be addressed in the Title III Evaluation Report of the North Portal Pad Drainage System.

3.2.1.2.4.A The ESF shall be designed in compliance with the applicable requirements contained in the Uniform Building Code.	Yes	The Muck pile has been designed in compliance with the applicable requirements of the UBC but it was not built in accordance with the design drawings. **Recommend:** Grade the muck pile per design drawings
3.2.1.2.4.B The ESF shall be designed in compliance with the applicable requirements contained in ACI 318 Building Code Requirements for Reinforced Concrete Code.	N/A	ACI 318 is mainly for building type structures and does not apply to the Muck Storage System.
3.2.1.2.4.C The ESF shall be designed in compliance with the applicable requirements contained in DOE Order 6430.1A.	N/A	DOE Order 6430.1A, General Design Criteria, does not apply to Muck Storage.
3.2.1.2.4.D The ESF shall be designed in compliance with the applicable requirements contained in DOE Order 5480.7A.	N/A	DOE order 5480.7A, Fire Protection, does not apply to Muck Storage.
3.5.4.1.A The muck storage area shall be sized to accommodate the calculated worst-case excavated muck transported from the subsurface.	Yes.	The area has been sized for the excavated muck plus an expansion factor and the constructed area complies with the design drawings.
3.5.4.1.B The muck storage site shall provide equipment or facilities for controlling dust generated as a result from muck displacement/storage.	Yes.	Equipment is provided by the Contractor for controlling dust. A water truck is used for the application of water when determined necessary by the Contractor. Water application is monitored by meters and recorded and reported in accordance with YAP-2.8Q, Tracers, Fluids and Material Data Reporting and Management.

3.5.4.1.C Muck haulage in the vicinity of the main site shall be separated from personnel access for safety considerations.	N/A	Muck is transported by overhead conveyor and it will be addressed in the Title III Evaluation Report for the Conveyor system.
3.5.4.1.D The Muck Storage System shall be designed in compliance with all applicable requirements in the Air Quality Operating Permit AP 9999-0076.	Yes.	The Muck Storage System was designed and constructed per the design drawings and specifications which require dust control.
3.5.4.1.E The Muck Storage System shall be designed in compliance with all applicable requirements in the Floodplain Assessment.	N/A	A review of Section 2.2.3 of the Floodplain Assessment shows that the statement "a perforated pipe collection system will be installed down the center of the pile to collect water from the rock and discharge it into a small, lined collection and evaporation basin at the northeast end of the site" does not apply to the Muck Storage System. **Recommend:** Revise the ESFDR to delete this portion of Section 2.2.3 from this requirement.

6.2 As-Constructed Deviations and Recommendations

Table 6-2 provides a summary of deviations between the as-constructed system and the A/E design drawings and specifications. Recommendations are provided for additional construction activities to resolve the deviations. Alternative means of mitigating the potential failure of the muck pile included consideration of retaining wall structures. These concepts were subsequently dismissed since the installation of these structures at the toe of the slopes would probably induce failure of the muck pile during construction of the retaining walls. The cost of these retaining structures is also considered unwarranted. The most practical and cost effective solution is to reduce the slope of the muck piles by flattening the slopes.

Table 6-2 As-Constructed Deviations and Recommendations

AS-CONSTRUCTED DEVIATIONS AND RECOMMENDATIONS		
As-Constructed Deviations	**Design Document**	**Recommendations**
The side slopes of the muck pile on the north half are not as specified on the design drawings. A topographic survey of the muck pile showed that in some areas the slopes are steeper than 2:1.	Ref 9.2	Grade side slopes as specified in the design drawings. A geotechnical report recommends that the side slopes of the muck pile be flattened to no steeper than 26° (2 horizontal to 1 vertical) in order to be stable under the design earthquake. See Attachment III.
The interception drainage ditch on the west side of the Muck Storage pile has not been installed.	Ref 9.3	The interception drainage ditch is required and it will be addressed in the Title III Evaluation Report of the North Portal Pad Drainage System.

7. SUMMARY OF RECOMMENDATIONS

7.1 ESFDR Modifications

7.1.1 Revise Appendix A of the ESFDR to change the seismic design of ESF temporary surface facilities to conform with the requirements of the Uniform Building Code (UBC) for Zone 2B instead of Zone 3.

7.1.2 Revise ESFDR requirement 3.5.4.1.E to delete the portion of Section 2.2.3 from the Floodplain Assessment that states "a perforated pipe collection system will be installed down the center of the pile to collect water from the rock and discharge it into a small, lined collection and evaporation basin at the northeast end of the site".

7.2 As-Constructed Deviations and Recommendations

7.2.1 Drainage will be addressed in the Title III Evaluation report for the North Portal Pad Drainage System.

7.2.2 Grade side slopes as specified in design drawings.

8. COST AND SCHEDULE ESTIMATES

8.1 The cost of grading the slopes of the north half of the muck pile is estimated at $12,592 and is based on an estimate made by the A&E.

8.2 Cost for revising ESFDR requirements will be included within cost of general revision of ESFDR document.

9. REFERENCES

9.1 Design Analysis Muck Storage Pad
BABCC0000-01717-0200-00001 Rev 02

9.2 Muck Storage
BABCC0000-01717-2100-20071 Rev 00 Site Plan
BABCC0000-01717-2100-20072 Rev 00 Site Grading Plan and Road
BABCC0000-01717-2100-20073 Rev 00 Site Grading Plan and Road
BABCC0000-01717-2100-20074 Rev 00 Site Grading Plan and Road
BABCC0000-01717-2100-20075 Rev 00 Site Grading Plan and Road
BABCC0000-01717-2100-20076 Rev 00 Site Grading Plan and Road

9.3 Optional Muck Storage Area
BABB00000-01717-2100-20082 Rev 01 Grading Plan, Sheet 1 of 2
BABB00000-01717-2100-20083 Rev 01 Grading Plan, Sheet 2 of 2
BABB00000-01717-2100-20085 Rev 01 Storm Drain Optional Storage Area Plan and Profile

9.4 YMP Baseline Document, Exploratory Studies Facility Design Requirements Documents, YMP/CM-0019, Rev 02

9.5 Specification Section 01800 Maintenance and Operations of Surface Facilities, Document Number BAB000000-01717-6300-01800 Rev 01

9.6 Topography of South End of Muck Pile ESF North Pad

9.7 Design Analysis Number BAB000000-01717-2200-00106 Rev 02 Determination of Importance Evaluation for the Surface Exploratory Studies Facility

9.8 State Nevada Stormwater General Discharge Permit, dated May 14, 1993

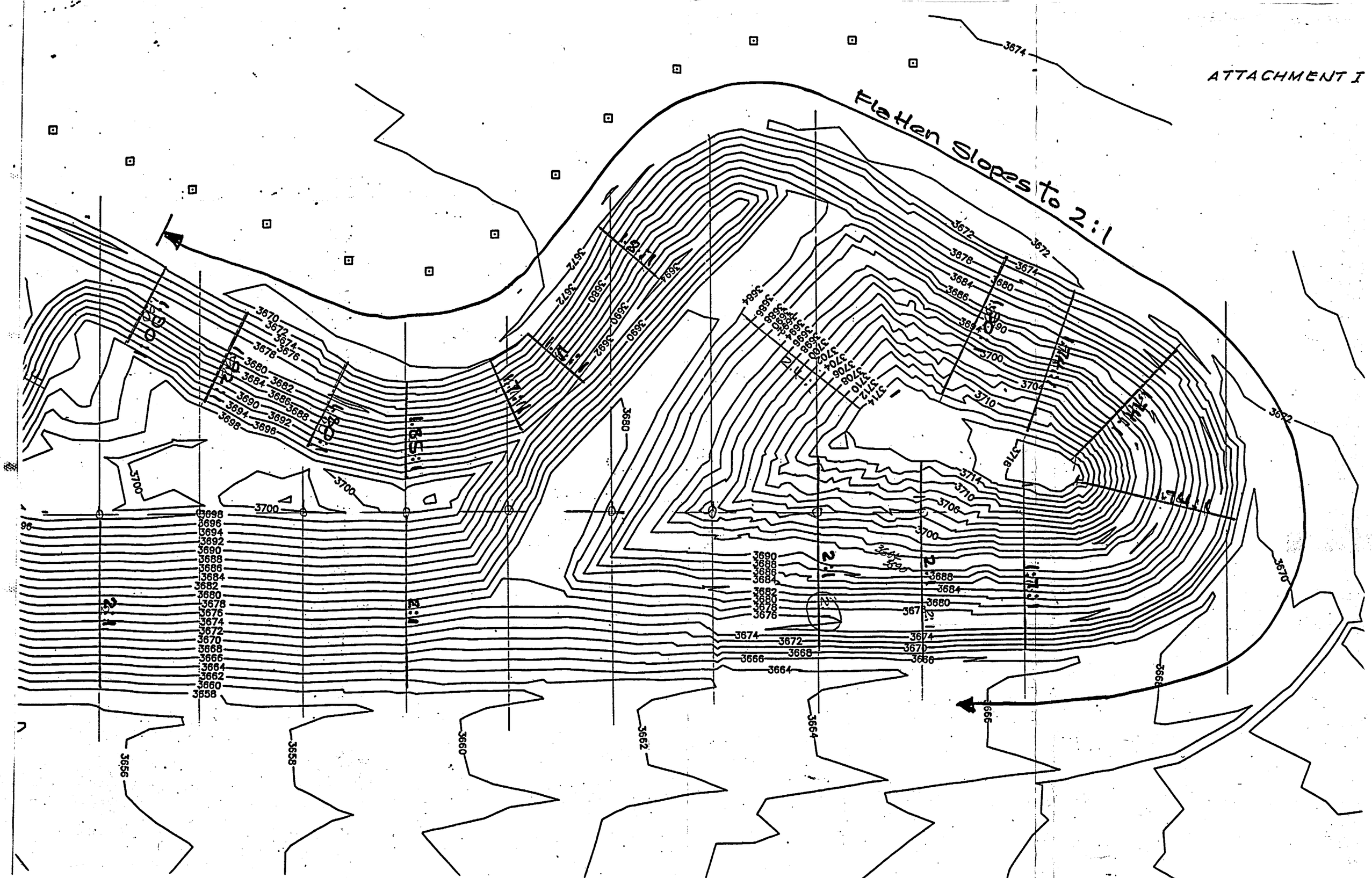
10. ATTACHMENTS

10.1 ATTACHMENT I - Muck Pile Plan showing location of 2:1 slope deviation.

10.2 ATTACHMENT II - Cost Estimate to flatten the slopes of the northern part of the muck pile to 2:1 (2 horizontal to 1 vertical).

10.3 ATTACHMENT III - Interoffice Correspondence, J. H. Pye to W. R. Kennedy, *Site Visit to Evaluate the Stability of the North Portion of the Muck Pile* M & O Document Identifier LV.ESSD.JHP.07/98-089, Civilian Radioactive Waste Management System, July 13, 1998.

ATTACHMENT I



Estimate to flatten the slopes of the northern part of the muck pile to 2:1. Estimated volume of material is 3,800 cubic yards.
Used a production rate of 150 cubic yards per hour. Estimated time to do work is: 3,800 cy / 150cy per hour = 25 hours
Also, assume 3,800 cy of material will have to be haul to the muck pile area south of the drainage ditch.

File: MUCKPILE

SPECS/ ITEM NO.	DESCRIPTION	CREW EACH	UNIT	MANHRS PER UNIT	QTY	TOTAL MANHRS	LABOR		EQUIP RENTAL		SUPPLIES		PERM MTLS		DIRECT COST	
							UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL	UNIT COST	TOTAL
	Foreman	0.25	EACH	0.25	25.00	6	10.83	271				0		0	10.83	271
	Dozer operator	1.00	EACH	1.00	25.00	25	41.72	1,043				0		0	41.72	1,043
	Front end loader operator	1.00	EACH	1.00	25.00	25	41.72	1,043				0		0	41.72	1,043
	Teamster	2.00	EACH	2.00	25.00	50	68.72	1,718				0		0	68.72	1,718
	Surveyor	1.00	EACH	1.00	25.00	25	41.60	1,040				0		0	41.60	1,040
	Laborer - flagman 2 @ 50% time	1.00	EACH	1.00	25.00	25	32.85	821				0		0	32.85	821
	Dozer	1.00	EACH	0.60	25.00	15	30.90	773			66.47	1,662		0	97.37	2,435
	Front end loader	1.00	EACH	0.38	25.00	10	19.57	489			18.51	463		0	38.08	952
	Truck - Bottom dump	2.00	EACH	0.60	25.00	15	30.90	773			23.10	578		0	54.00	1,351
	SUBTOTAL					196		7,971		0		2,703		0		10,674
	SUBTOTAL DIRECT COST					196		7,971		0		2,703		0		10,674
	G&A EXPENSES	0.06						478		0		162		0		640
	FEE	0.05						422		0		143		0		565
	PM&I	0.06						532		0		180		0		713
	SUBTOTAL MARKUPS							1,432		0		485		0		1,918
	TOTAL ESTIMATED COST							9,403		0		3,188		0		12,592

ATTACHMENT II

Interoffice Correspondence

Civilian Radioactive Waste Management System
Management & Operating Contractor

TRW

ATTACHMENT III

TRW Environmental
Safety Systems Inc.

WBS: 1.2.6
QA: N/A

Subject:
Site Visit To Evaluate the Stability of the North Portion of the Muck Pile

Date:
July 13, 1998
LV.ESSD.JHP.07/98-089

From:
J. H. Pye JHP

To:
W. R. Kennedy

cc:
Jerry Keifer
Hector Montalvo
RPC= Total Pages 2

Location/Phone
Sum1/423
(702)295-4240

On Tuesday, May 5, 1998, Grant Cherrington, John Pye, Hector Montalvo, Ed Fitch and Marek Mrugula visted the EFS facility. The purpose of the visit was to examine the muck pile and evaluate the need to flatten the slopes of the north portion of the pile to ensure stability during an earthquake. The following is a summary of the inspection.

The muck in the pile is a heterogeneous mixture of sand through angular rack fragments with a maximum size of approximately 2 feet. Since the pile has a relatively level base, it is assumed that there is no free moisture in the pile and, for analysis purposes, it is dry. It is also assumed that the underlying material has a higher strength than the material in the pile and that any stability failures would be within the pile.

A preliminary survey of the muck pile using a Brunton showed that the south half of the pile has slopes which have been flattened to an angle of approximately 23^0 with the horizontal which is equivalent to a slope of 2.35 horizontal to 1 vertical. This slope gives a factor of safety of approximately 1.2 against failure from a design earthquake horizontal acceleration of 0.2 g [The EFS facility is located in Zone 2B, which has an assigned horizontal earthquake acceleration of 0.2] and an assumed friction value for the muck in the pile of 40^0. A detailed topographic survey subsequently produced by Peter Kewit [DRN No SUA BLP 16A] showed that the slopes were typically between 2.1 – 2.2 horizontal to 1 vertical.

The north half of the pile is somewhat irregular in shape with slopes varying between 30^0 and 40^0 and an estimated maximum height of 50 feet. The north face of the pile incorporates two benches resulting in an overall slope of approximately 30^0. Based on the previously stated earthquake acceleration of 0.2 g and an assumed friction value for the muck of 40^0, the factor of safety of the north face (using an infinite slope analysis for a dry slope from the U.S. Army Engineering Manual 1110-2-1902 of April 1, 1970) is estimated to be 0.95. In order to have a minimum acceptable factor of safety during a design earthquake, it will be necessary to also flatten the slopes on the north half of the pile to no steeper than 26^0 (2 horizontal to 1 vertical).

Any failure of the slopes of the muck pile which border the access road could endanger traffic driving along the road as well as blocking the road. Consequently, it is recommended that the slopes on the muck pile (particularly those bordering the road) should be flattened to no steeper than 26^0 (2 horizontal to 1 vertical) in order for the muck to be stable under the design earthquake.

Alternative means of mitigating the potential failure of the muck pile included consideration of retaining wall structures. These concepts were subsequently dismissed since the installation of these structures at the toe of the slopes would probably induce failure of the muck pile during construction of the retaining walls. The cost of these retaining structures is also considered to be unwarranted. The most practical and cost effective solution is to reduce the slope of the muck piles as previously proposed.

A survey of the muck pile was completed to provide a topographic map. Based on a topographic map prepared on May 20, 1998 on the north half of the muck pile, the quantity of material which will have to be moved to achieve a slope of 2 horizontal to 1 vertical for the north half of the pile is approximately 3800 yd^3.

JHP/mmc